REMARKS

The Office Action dated September 8, 2006, has been carefully considered. Claims 28-58 are currently pending. Applicant requests that the Examiner consider the following remarks, and then pass the application to allowance.

Interview Summary:

The Applicant thanks the Examiner for the courtesy of the telephonic interview on December 13, 2006. During the interview, the ability of an infra-red light source having an operational wavelength of greater than 1000 nm to measure substrates having a thickness of between 1 and 1000 microns was discussed in view of the prior art. No agreement was reached.

Claim Rejections - 35 U.S.C. § 103

Claims 28-54 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Li et al. (U.S. Patent No. 6,392,756) in view of Edgar et al. (U.S. Patent No. 4,885,709) and Adams (U.S. Patent No. 4,899,055).

The present invention provides an optical spectroscopic measurement system used to precisely determine the thickness of a layer of material and a method of measuring material thickness using the system. This invention solves the problem of direct measurement of the thickness of such a layer, done with a non-contact, optical technique, with a high degree of accuracy by using an infrared light, which is able to partially transmit through the measured materials. See pages 3 and 4 of the Specification.

As recited in Claims 28, 37, and 49, the system and/or method is comprised of a tunable infra-red light source able to vary its wavelength in increments of less than 1.0 (or 0.5 nm), and wherein the wavelength of operation of the light source is greater than 1000 nm. In order to measure materials having a thickness of 1 to 1000 microns, the wavelength tuning increment of the light source is critical, since as the thickness of the layer to be measured increases, the oscillations in the reflectivity caused by (Fabry-Perot) interference increase in frequency. In addition, in order to detect these oscillations, fundamental engineering theorems (Nyquist and Whittaker-

Shannon sampling) require that the sampling frequency be at least twice that of the highest analog frequency to be reconstructed (or modeled).

Furthermore, the laser or light source must be tuned in wavelength steps much smaller than the wavelength period of the reflectivity oscillations. For example, to measure a 500 micron thick silicon wafer, the wavelength steps should be smaller than about 0.2 nanometers at the 1550 nm center wavelength. Thus reducing the increment size has the effect of increasing the thickness which may be measured. In addition, the bandwidth of the wavelength range, hence the total number of points, affects the thinnest layer which may be measured and also, to a lesser extent, the accuracy of the measurement. Thus, to measure a 10 micron thick layer of silicon, a wavelength tuning range of about 100 nm (1500 to 1600 nm absolute in my example) is needed.

It can be appreciated that by reducing the wavelength increment, therefore, increases the thickness, which may be measured. However, this is a very different from the case of thin films, which has not been addressed in the prior art. For the thin films, reducing the wavelength increment has the effect of slightly improving the accuracy due to better modeling of the reflectivity data. However, until recently, no practical method of high resolution, infrared spectroscopy existed. The established technology achieves only moderate resolution by use of a broadband source and use of gratings. Thus, the technology failed to measure materials including silicon layers having thicknesses in the range of 1 to 1000 microns. The present application inverts this by utilizing a high resolution, tunable laser source and a broadband detector. See Declaration of Glenn Houser submitted herewith.

Claim 28 recites a spectroscopic system for measuring thickness of a planar material using interferometry internal to the material, the system comprising: <u>a quasi-monochromatic, tunable infra-red light source which provides wavelengths of light varied in increments of less than 0.5 nm</u>; a photodetector that detects light reflected from or transmitted through the material; a computing device to calculate the material's transmission or reflectivity based on an interference signal from the photodetector, and wherein the material's transmission or reflectivity is used to calculate the thickness of the material based on a knowledge of a material's refractive data; and <u>wherein the material to be measured has a thickness of 1 to</u>

1000 microns, and the wavelength of operation of the light source is greater than 1000 nm. (Emphasis added).

Claims 37 recites a spectroscopic system for measuring thickness of a planar material using interferometry internal to the material measured comprising: a quasi-monochromatic infra-red light source able to vary its wavelength in increments of less than one nanometer; a photodetector to measure the reflected or transmitted light; a computing device to calculate the material's transmission or reflectivity based on the interference signal from the detector, and wherein the material's transmission or reflectivity is used to calculate the thickness of the material based on a knowledge of a material's refractive data; and wherein the material to be measured has a thickness of 1 to 1000 microns, and the wavelength of operation of the light source is greater than 1000 nm. (Emphasis added).

Claim 49 recites a method of measuring material thickness, wherein the method comprises: a method of measuring material thickness, wherein the method comprises: loading a material to be measured into a holder of a spectroscopic system, the material having a thickness of 1 to 1000 microns, wherein the system comprises: a quasi-monochromatic infra-red light source having a wavelength of operation of greater than 1000 nm, and wherein the light source is able to vary its wavelength in increments of less than one nanometer; a photodetector to measure the reflected or transmitted light; and a computing device to calculate the material's transmission or reflectivity based on the interference signal from the detector, and wherein the material's transmission or reflectivity is used to calculate the thickness of the material based on a knowledge of a material's refractive data; measuring the light reflected from or transmitted through the material at at least two different wavelengths using the photodetector; and computing material thickness using a computing device based on data received from the detector. (Emphasis added).

Li relates to methods and apparatus for optically determining physical parameters of thin films deposited on a complex substrate, and in particular to measurements of thin films on complex substrates for obtaining physical parameters such as thickness t, refraction index n and extinction coefficient k. In Li, the method calls for providing a test beam having a wavelength range and providing a complex substrate, which has at least two layers and exhibits a non-monotonic and an

appreciably variable substrate optical response over wavelength range. As set forth in Li, the "[l]ight source 56 can be a tunable laser or any other suitable light source or combination of light sources for producing a stable light wave spanning a wave-length range delta lambda., e.g., from 190 nm to 900 nm." Col. 8, lines 43-46. In addition, "[t]ypically, wavelengths range $\Delta\lambda$ is selected from 190 nm to 900 nm in 1 nm intervals." Col. 7, lines 62-63. Li also states that "it would be very desirable to provide a non-destructive measurement method for determining film thickness to an accuracy of 5 to 2 Angstroms or less in films whose thickness is less than 100 Angstroms or even less than 10 Angstroms." Col. 3, lines 4-8. Li, however, does not teach or suggest a tunable infra-red light source able to vary its wavelength in increments of less than 1.0 nm (0.5 nm), and wherein the wavelength of operation of the light source is greater than 1000 nm.

Edgar relates to a computational method and apparatus for sensing or determining one or more properties, or the identity of a sample in which electromagnetic radiation is subject to optical interference, absorption or scatter. As set forth in Edgar, the method and/or apparatus correlates the measured values with different known values of relevant transmittance or reflectance to sense or determine material thickness of <u>about 10 microns</u>. (Col. 13, line 65 - col. 14, line 1). Edgar, however, does not teach or suggest the use of a tunable laser or light source for use with materials having a range of thickness of 1 to 1000 microns nor even a method of measuring parameters such as reflectivity or thickness.

Adams relates to a method of measuring thin film thickness, especially on semiconductor substrates, in which the substrate is illuminated with ultraviolet light of a fixed wavelength corresponding to a persistent spectral line and the amount of light reflected from the substrate is detected and measured. The ultraviolet light preferably has a wavelength in the range from 240 nm to 300 nm.

Claims 28, 37, and 49, each recite a tunable laser source which has the characteristics of a small tuning increment (less than 1nm) and a wide bandwidth (greater than 1000 nm), which is not taught or suggested by any of the cited references, including the use of tunable laser for the measurement of wafer thicknesses of 1 to 1000 microns. In addition, there is no teaching, suggestion or motivation to modify Li to include a tunable light source having a wavelength of

greater than 1000 nm, since the method and apparatus of Li is useful in the measurement of materials having a thickness of less than 100 Angstroms. Accordingly, since the wavelength increment is critical, and not merely a matter of choice, Claims 28, 37 and 49 should be allowable. Claims 29-36, 38-48, and 50-54 are dependent from Claims 28, 37 and 49, respectively, and should also be allowable for the reasons set forth above.

Claims 55-58 were rejected under 35 U.S.C. §103(a) as being unpatentable over Li et al. (U.S. Patent No. 6,392,756), Edgar et al. (U.S. Patent No. 4,885,709) and Adams (U.S. Patent No. 4,899,055), as applied to claim 49 and further in view of Ruhl, Jr., et al. (U.S. Patent No. 5,357,336).

Claims 55-58 are dependent from Claim 49, and for the reasons set forth above, should also be allowable.

CONCLUSION:

In the event that there are any questions concerning this response or the application in general, the Examiner is respectfully urged to telephone the undersigned attorney so that prosecution may be expedited.

Respectfully submitted,

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Date: December 29, 2006

By: [signature]

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